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THE USE OF STEEL PIPE IN WATER WORKS[1]

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The subject of steel pipe is a broad one upon which volumes might be written. There are many subdivisions of the matter, any one of which would furnish the text for a paper in itself. Probably a brief discussion of some of the points that have been observed, or followed in practice, might be of interest. Necessarily the paper will deal with Western experience, more particularly with that on the Pacific Coast. Most of the experience of the writer regarding the life of plate pipes, has been in connection with riveted wrought iron mains. The early use of pipes of this sort in the West was in connection with hydraulic mining. Although the date cannot be definitely fixed, it is believed that as early as 1852 riveted iron pipes were used in the hydraulic mines of California. The plates for many of these pipes were imported from England. Due to the fact that the field joints were telescoped, the pipe was known locally as "stove pipe." Although hydraulic mining was discontinued many years ago, some of these old pipes were still in use for local water supplies in the small mountain villages a few years ago. The writer has examined some of them over sixty years old, and while in general

[1] Presented before the Philadelphia Convention, May 19, 1922.

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the coating had practically disappeared, the metal showed only a very slight, evenly distributed rusting, with but little pitting.

The Spring Valley Water Company was one of the early users of riveted pipe. Under the direction of Mr. Hermann Schussler, then Chief Engineer of the Company, a 30-inch no. 12 gauge riveted iron pipe, 15 miles long, was laid in 1868. The last mile of this main was replaced early this year, after having been in continuous use for fifty-four years. Fully 60 per cent of this section was in very good condition upon removal. At the present time 8 miles of 30-inch no. 12 gauge riveted iron pipe, laid in 1870, is used in bringing part of the supply to San Francisco. A still later riveted iron pipe is the 44-inch no. 6 gauge line, now 37 years old, used as part of the supply system, and which, so far as can be ascertained from frequent inspection, seems to be in practically as good condition as the day it was laid. All of these pipes are laid in a light, well drained soil free from alkali. Since 1888 this Company has used two 16-inch submarine lines of steel tubing crossing San Francisco bay. These lines are about 6000 feet long, and at very low tides are open to inspection for a part of their length. No signs of deterioration can be detected, the only mark apparent to the eye being a slight dent in the top of one pipe, caused by the keel of a small schooner.

The writer attributes the long life of these plate pipes to the coating and the character of the soils in which they are laid. The pipe dip used for the mains listed above, is one developed many years ago, consisting of a heated mixture of coal tar and asphaltum.[3] Later pipes laid in western cities have been dipped in ordinary asphaltum, a by-product of the refining of crude oil. This latter dip seems to become brittle and scales off, particularly during the handling of the pipe from the pipe works to the trench. During the past few years the custom of wrapping the dipped pipe with a composition paper has become prevalent. It costs only a few cents a foot additional, but is well worth the expenditure as an insurance against the breaking off of the coating next to the metal. Experience in connection with some of the long steel pipe lines laid in the alkaline soils of the San Joaquin Valley, which have been dipped in asphaltum and wrapped, indicates that the wrapping is well worth while. Probably a description of the method of using this protective covering would be of interest.

[3] Detailed description of dip and method of application, see page 323 "Waterworks Handbook," Flinn, Weston and Bogert.

After manufacture, the pipe is to be cleaned of dirt, scale and rust, and dipped in asphaltum at a temperature of 360° F. and is to remain in the kettle until the metal has attained the temperature of the bath. After the pipe has been dipped it is to be spirally wrapped with mica covering, wrapping to be put on under a tension of not less than fifty (50) pounds per eighteen (18) inches width of wrapping. The ends of the wrapping at the joint connections are to be finished off by sealing with hot asphaltum.

The mica covering shall be of felt, which has been thoroughly saturated with a high melting point bituminous compound, containing not less than twenty-five (25) per cent by weight of an alkali resisting mineral. The finished product shall weigh not less than three and six-tenths (3.6) pounds per square yard. Flaked mica shall be applied to the side of the coating which will be on the outside of the pipe, in such quantities as to give the best results.

A twelve (12) inch strip of the covering long enough to give a four (4) inch longitudinal lap is to be furnished with each section of pipe, together with the necessary asphaltum for wrapping and sealing the field joints.

The cost of wrapping a 30-inch pipe in addition to dipping, was 30 cents per lineal foot.

In general, the long life of the pipes mentioned above may be ascribed to the coating. The submarines have now been exposed to the action of salt water for over 30 years, without any evidence of deterioration. This pipe was galvanized and then dipped with a double coat of coal tar and asphaltum mixture. It has been the experience of the writer that where plate metal pipes have been carefully coated with a satisfactory protective covering material, and then laid in ordinary well drained, light soils, it is not unreasonable to expect a life of from forty to fifty years. A good coating will withstand the effect of a certain amount of alkali, but this is a matter of degree and instances are not wanting where pipes have been seriously attacked in less than five years. A satisfactory protective coating is just as important as a proper grade of metal.

In addition to other factors, the use which a pipe is to be given has a considerable effect upon the life. By use is meant the distinction between mains laid in the distributing system and those used for the transmission of the supply from the source to the city reservoirs. All of the examples given above are of pipes laid for transmission purposes; in other words, the pipes when laid are usually undisturbed for long periods of time. In the distributing system, mains are subject to more or less disturbance and exposure due not only to the operations of the waterworks in making connections, but are also exposed to damage from the work of other utilities. Careless handling of excavating tools often results in at least a

scratch clear through the coating, if not the removal of several square inches of surface, with the inevitable result that pitting and rusting begin immediately. With the smaller steel mains the connections for services are often responsible for the beginning of corrosion.

At present prices it is doubtful whether it pays to use steel pipes in the distributing system so far as the smaller sizes, such as 6 to 12-inch diameters, are concerned. Of course, frieght enters largely into the final cost of material, particularly that which is used on the Pacific Coast. A steel pipe of any type of sufficient thickness to stand the wear and tear of handling during its life, will cost as much

FIG. 1. PLACING A 200-FOOT LENGTH OF PIPE IN THE TRENCH

in place as a cast iron pipe of similar size. For the larger sizes this is not the case, however, and under some conditions steel is as desirable as any other metal. In practically all large cities a percentage of the larger distributing mains is riveted pipe. In San Francisco one of the principal feeders from the distributing reservoirs is a riveted main, tapering from 44 to 30-inch diameter. Excepting a replacement of about 1000 feet necessitated by electrolysis, the main is in very good condition after thirty-seven years of use. This pipe, however, is not tapped for service connections and consequently is not disturbed. All cross connections to street mains were made at the time the pipe was laid.

The general use of modern welding methods has done much to popularize the use of steel pipe. For the last four years the Spring Valley Water Company has used a welded field joint on riveted

pipe in preference to either the riveted or lead filled joint. Contrary to expectations, the heat of the welding did not open up the longitudinal riveted seam at the joint. The practice is to weld together enough lengths to make about 200 feet of pipe on the edge of the trench, and then lower the piece into place. The number of bell holes is reduced, and the ease of working on the level ground rather than in a hole results in greater speed and reduced costs. A recent 30 by $\frac{3}{16}$ inch line cost per joint for labor and material $6.00

FIG. 2. AN 8-INCH OUTLET BRANCH WELDED ON THE UPPER HALF OF A 30-INCH MAIN IN ORDER TO AVOID A PARALLEL 4-INCH GAS PIPE

for welding, as compared to $8.00 for a riveted joint. All of the outlets from this main were made by cutting and welding appropriate sized pieces of steel tubing to the side of the main. In a distributing system this is a great help, as at street intersections where other underground utility structures parallel the pipe, the connections were made near the top or bottom of the 30-inch main, thus enabling the branch pipe to pass over or under the obstruction without the use of bends. Not only was the welding process used for making joints and connections, but all of the bends were made in

the field by the use of the same agency. To make a 90 degree elbow for instance, a piece of straight 30-inch pipe of sufficient length was taken and four wedge shaped cuts, each covering an angle of $22\frac{1}{2}$ degrees, were marked with chalk. These pieces were then burned out of the pipe, leaving however a small untouched strip about 2 inches long at the back of the pipe at what would be the apex of the angle, for the purpose of holding the four pieces in place. The remainder of the operation consisted of bending the pipe until the

Fig. 3. A 90 Degree Bend Made in the Field From a Piece of Straight 30-Inch Pipe by Burning Out Sections and Welding

edges were in contact and welding them. The convenience of this method alone would suggest its use, but there is no doubt that taking the cost of the work as a whole, a substantial economy was effected. The pre-determination and purchase of angles, where large riveted pipe is laid in city streets, has never been satisfactory in the writer's experience, as one never knows until the trench is excavated just what artificial obstructions are to be overcome. The delay incidental to necessary changes is reduced to a minimum with a welding outfit on the job.

It may be of some interest to discuss briefly the effect of age on the carrying capacity of large plate pipes. This is a subject which has received a great deal of competent investigation. There appears to be a somewhat different experience in various parts of the country in the progressive reduction of carrying capacity. Some of the Western waters seem to produce this effect to a smaller degree than is customarily expected. Some years ago tests were made on several riveted lines in the vicinity of San Francisco to determine accurately their carrying capacity. All of these pipes had been dipped with the mixture of coal tar and asphaltum mentioned before. The results obtained are summarized in the following table.

SIZE	LENGTH	AGE	WILLIAMS AND HAZEN VALUE OF "C"
inches	*miles*	*years*	
36	21.5	23	107.5
36	6.7	23	123.0
54	3.2	8	109.0
44	5.1	27	97.9
44	4.3	27	89.1
44	5.5	13	113.5
30	7.5	42	110.0
30	5.0	4	114.0
30	1.0	46	110.0

The two instances where the value of "C" was below 100 occurred in pipes that had a large number of both horizontal and vertical bends, and in one case a piece of 37-inch diameter was necessarily included in the length tested. In general the interior of all of these pipes is in very good condition. Experience with plate pipes on the Pacific Coast shows that nearly all deterioration is from the surrounding soil and very seldom occurs to any great degree on the inside. Sponge growth occurs at certain seasons on the interior of the pipes. Apparently, in the case of the pipes tested, neither growths nor deterioration had a marked effect on the carrying capacity.

The writer's preference is for cast iron mains for general use in the distributing system, particularly those which are to be tapped for services. However, for transmitting the supply from the source to the distributing system, and possibly the large feeder mains in the distributing system, particularly in locations not subject to frequent disturbance, the plate metal pipe has many advantages which recommend its use.